Table 4. Effect of fertilization on the yield of cultivated grassland (mixture F and G).

Mixture	Fertilization	Yield, kg DM/ha Average	Range	kg DM/kg NPK
	$N_{87}P_{60}K_{60}$	7,859	5,465 to 9,130	20.0
F_1	$N_{174}P_{120}K_{120}$	10,308	7,228 to 12,403	15.9
	$N_{260}P_{180}K_{180}$	11,430	8,046 to 12,870	12.4
	Control	3,719	2,912 to 4,800	–
	$N_{87}P_{60}K_{60}$	6,794	5,367 to 7,860	13.7
G_1	$N_{174}P_{120}K_{120}$	9,023	6,278 to 11,160	12.2
	$N_{260}P_{180}K_{180}$	10,680	7,452 to 12,517	10.8
	Control	3,957	2,952 to 4,112	–

[1]See Table 3 for composition of mixtures.

Table 5. Effect of fertilization on the yield of cultivated grassland, Mountain region.

Fertilization	DM yield, kg/ha Average	Range	kg DM/kg NPK
$N_{80}P_{50}K_{50}$	7,940	6,432 to 8,710	18.9
$N_{150}P_{100}K_{100}$	10,413	7,920 to 12,400	17.2
$N_{220}P_{150}K_{150}$	11,720	8,860 to 12,960	14.1
Control	4,470	3,070 to 5,343	–

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Grass and Forb Production on Sprayed and Nonsprayed Mesquite (*Prosopis glandulosa* Torr.) Dunelands in South-Central New Mexico

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Summary

Production of grasses and forbs was measured for 4 years, beginning in 1976, following aerial application of 2,4,5-T to 3,634 ha of mesquite (*Prosopis glandulosa* Torr.) dunelands on the Jornada Experimental Range in south central New Mexico. Plant production was also measured on a 3,318-ha control area. The mesquite dunelands are representative of large areas in the southwestern U.S.A. where mesquite has invaded former desert grasslands. Objectives of the study were to determine forage increases attributable to reduced mesquite competition and to evaluate the relationships between production and precipitation.

Both sprayed and control areas were grazed by cattle. Temporary exclosures were used to exclude cattle from three sampling sites on the sprayed and control areas each year. The sampling sites were all on sandy ranges with relatively deep soils (>50 cm to caliche layer). A dune-centered sampling system permitted the determination of differences in production on dune and interdune areas. The mesquite dunes, occupying 28% of the land surface, produced more annual forbs and fewer perennial grasses than the interdune areas. Stem kill of mesquite averaged 56% at sampling sites on the sprayed area. End-of-season harvests were used to compare treatments.

Perennial grass production was 7-, 8-, and 4-fold greater on the sprayed than on the control area in the first 3 years following treatment, respectively. Maximum perennial grass production of 642 kg/ha occurred in the first season following treatment. In the 4th year the control area received 49 mm more precipitation than did the sprayed area, and production of perennial grass

was nearly equal on the two treatments. Mesa dropseed (*Sporobolus flexuosus* [Thurb.] Rydb.) contributed 66%-92% of the perennial grass production. Production of annual plants varied widely among years but was greatest in the 4th season when precipitation patterns favored annual plant growth, particularly on the control area where annual forb production was 543 kg/ha. Production of broom snakeweed (*Xanthocephalum sarothrae* [Pursh] Shinners) cycled from high to low and back to high on both treatments.

Mesquite control is an effective tool for improving forage production on arid rangelands, but the success of control efforts depends not only upon the degree of brush kill but also upon the posttreatment precipitation patterns.

KEY WORDS: mesquite, *Prosopis glandulosa* Torr., mesa dropseed, *Sporobolus flexuosus* (Thurb.) Rydb., 2,4,5-T, forage production.

INTRODUCTION

Mesquite (*Prosopis glandulosa* Torr.) has invaded and become dominant on large areas of once-productive rangeland in the southwestern U.S.A. Brush invasion has seriously reduced the carrying capacity of rangelands and has a serious impact upon the region's economy. It is imperative to control the invading brush and return the land to a productive condition if food and fiber demands are to be met.

The invasion of brush species in the Southwest during the past 100 years has been well documented (Brown 1950, Glendening 1952, Dick-Peddie 1966). Estimates indicate that mesquite is a serious problem on 37.6 million ha of rangeland (Platt 1959). Overgrazing in the late 1800s and early 1900s is often cited as a cause of brush invasion, but there is ample evidence that the invasion has continued even on well-managed, conservatively grazed ranges (Buffington and Herbel 1965). The invading brush species have been the object of control measures for many years (Fisher et al. 1959, Valentine and Norris 1960, Herbel and Gould 1970).

This study of primary production following mesquite control is part of a comprehensive program to determine the impact of mesquite control upon a grazing-land ecosystem. Included in the study were evaluations of the impact of mesquite control upon bird, insect, small mammal, and soil microorganism populations and livestock activities and production. It was conducted on the Jornada Experimental Range, located 37 km north of Las Cruces, New Mexico. The Experimental Range has an arid climate with 55% of the average annual precipitation of 231 mm occurring in July, August, and September.

METHODS

The mesquite control treatment consisted of two aerial applications of 0.56 kg 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid]/ha in a 1 : 7 diesel oil : water emulsion at a total volume of 9.4 l/ha. This treatment was applied to 3,634 ha of mesquite dunelands, and an adjacent area of 3,318 ha served as a control. The herbicide treatments, which were applied in early June, were begun in 1975 and were completed in 1978. Due to overlap of applications the sprayed sites monitored for grass and forb production received herbicide applications in 1975, 1976, and 1977. However, average stem kill of mesquite at the sampling sites was only 56%, which was representative of mesquite kill on the entire sprayed area.

Grass and forb production was measured at three sites in both the sprayed and the control area. All study sites were located on a sandy range site with either Typic Haplargid (Onite series) or Calciorthid (Wink series), coarse-loamy mixed, thermic soils. These relatively deep soils are generally more than 50 cm to the caliche layer. Temporary exclosures 0.4 ha in area were built at each site to prevent livestock grazing during the sampling season. The exclosures were moved to a new location each year. Utilization of forage by livestock during 1975–1977 was light to moderate at each site. A recording, weighing-type rain gauge was installed at each exclosure. Within each exclosure the mesquite dunes were marked with numbered stakes. At each sampling date three dunes in each exclosure were drawn at random for sampling. Precipitation patterns determined sampling dates, which varied from three to four/season.

Since it was necessary to measure production on both dune and interdune areas, a dune-centered sampling system was used. The point of a wedge-shaped clipping frame was placed at the center of a dune, and the angle subtended by the sides of the frame (18.4°) included a proportional sample of the center and periphery of the circular-shaped dunes. Herbaceous and shrublike plants were harvested from the wedge-shaped area in each of the cardinal directions on each dune. At the base of the dune a 1-m-wide transect was clipped that extended across the interdune area halfway to the next dune, also in each of the cardinal directions. The dunes had an average height and diameter of 1 and 5.4 m, respectively.

All plants were harvested at ground level and segregated by species. The clipped samples were separated into current growth and standing dead components, and oven-dry weights were determined (60°C). Because fluffgrass (*Erioneuron pulchellum* [H.B.K.] Tateoka) is very difficult to separate into live and dead components, weights for this species are for total standing vegetation. The suffrutescent broom snakeweed (*Xanthocephalum sarothrae* [Pursh] Shinners) , and the shrublike soaptree yucca (*Yucca elata* Engelm.) were separated into live and dead components. Canopy of the shrublike species occurring within the plots was harvested; all other species were harvested only if rooted within the plots. Mesquite was not harvested. An average of 190 m^2 was

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sampled on each treatment/collection date.

Since plot size varied, yield/unit area was calculated for dune and interdune areas. On both treatments, production on the mesquite dunes differed from that on interdune areas. In general, there were more annual forbs and fewer perennial grasses on the dunes. Production for the treatments has been calculated on the basis of 28% dune area, which is the average value for dune area on the two treatments.

The study extended from 1976 through 1980. At this time production samples for the years 1976–1979 have been processed. The end-of-season harvest (late September or early October) is selected for presentation. Most of the annual plants on the study area function as summer annuals, and the end-of-season harvest represents the peak standing crop of all perennials and annuals with the exception of one annual forb.

RESULTS AND DISCUSSION

The mesquite dunelands support a very small flora. Only five perennial grasses, three annual grasses, twelve perennial forbs, twenty-two annual forbs, and seven shrubs or shrublike species were encountered in the 4 years of sampling. Not all annual species were present in any one year. The amount and timing of precipitation appeared to be the factor determining which of the annual species were present.

Annual precipitation in 1974 was 404 mm (long-term average, 231 mm), and many seedlings of mesa dropseed (*Sporobolus flexuosus* [Thurb.] Rydb.) became established. Defoliation of the mesquite by herbicide in 1975 permitted the seedlings to develop. Thus, in the first year following treatment (1976), perennial grass production was 7-fold greater on the sprayed area than on the control area (Table 1), and in 1977 it was 8-fold greater, although production from both treatments in 1977 was less than in 1976 because of low precipitation.

In 1978 the control area received 36 mm more precipitation than the sprayed area, resulting in increased production of mesa dropseed on the control area. However, mesa dropseed production was still 4-fold greater on the sprayed area than on the control area. Death of plants in the mature population of broom snakeweed on both treatments caused a sharp drop in the production of shrublike species in 1978 (Table 1).

Normal precipitation occurred during the fall and winter of 1978–1979. This, plus favorable summer precipitation, led to the development of large populations of annual plants on both treatments. The control area received 49 mm more precipitation than the sprayed area in 1979. The additional soil water led to a tremendous stand of Russian thistle (*Salsola kali* L.) on the mesquite dunes in the control area, production of this species being as high as 396 g/m^2. Large numbers of broom snakeweed seedlings that became established in 1978 and 1979 grew rapidly, leading to a great increase in production of shrublike species on both treatments in 1979 (Table 1). Fluffgrass, the second most abundant perennial grass, increased on both treatments in 1979. Mesa dropseed production on the control area was nearly equal to that on the sprayed area in 1979. Mesa dropseed on the sprayed area began to die out in 1979; competition for soil water by the dense stand of annual plants was no doubt a factor contributing to the mesa dropseed mortality.

Overall, the herbicide treatment resulted in greatly increased production of mesa dropseed, which is an excellent forage species, for 3 years. The importance of amount and timing of precipitation in this arid region is evident from the fact that production of the control area in 1979 exceeded that of the sprayed area. Mesquite control is an effective tool for improving forage production on arid rangelands, but the success of such control depends not only upon the degree of brush kill but also upon post-treatment precipitation patterns.

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Table 1. Production (kg/ha) of grasses, forbs, and shrub-like plants on sprayed and on control areas in the first 4 years following application of 2,4,5-T for control of mesquite. Production on both sprayed and control areas calculated on basis of 28% dune area and 72% interdune area. Crop-year precipitation (October–September) is shown.

	1976		*1977*		*1978*		*1979*	
	Sprayed	*Control*	*Sprayed*	*Control*	*Sprayed*	*Control*	*Sprayed*	*Control*
Mesa dropseed	589	80	289	25	442	109	329	326
Other perennial grasses	53	9	36	13	59	70	84	106
Annual grasses	1	5	1	5	T†	1	T†	T†
Perennial forbs	12	5	3	2	4	11	34	12
Annual forbs	30	9	97	11	13	26	263	543
Shrub-like plants	297	234	239	100	49	39	188	161
Total production	982	342	665	156	567	256	898	1,148
Precipitation (mm)††	284	240	180	187	211	247	333	382

†T = Trace, < 0.5 kg/ha

††Long-term average for years 1915–1979 is 231 mm.

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Use of Fodder-Production Models for Mineral Soils on Grassland and Arable Land

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Summary

In four regions of Poland experiments begun in 1973 and planned to last 12 years compared cutting and grazing yields of permanent grasslands over 20–30 years old to yields of seven field fodder-production models. The models had 3-, 4- and 6-year rotations. The experiments were located on mineral soils with 28%–50% silt and clay and 2.1%–3.5% humus. The water table depth varied from 44 to 170 cm in spring and from 115 to more than 175 cm in summer. Average precipitation was 375–515 mm during the growing season (April-October) and 523–658 mm annually. Average annual fertilization/ha was as follows: N, 360 kg; P_2O_5, 150 kg; and K_2O, 280 kg. Experiments used the randomized-block method with 4 replications of 36 m^2 plots (82 m^2 gross).

Results after 8 years showed that the average annual yields of green matter were 54–75 t/ha (t = 1000 kg); fodder beet roots, 116–135 t/ha; potatoes, 30–39 t/ha; and broad bean seeds, 3.1–3.5 t/ha. Calculated in comparable units, the yields of digestible protein were higher in pastures and meadows (1.6 t/ha) than in the other models (0.98–1.16 t/ha). Yields of starch from meadows were 7.2 t/ha; from pastures 6.0 t/ha; and from field models 5.8–7.6 t/ha. Starch and protein yields calculated in cereal units were 12.7 t/ha from meadows, 11.2 t/ha from pastures, 11.8 t/ha from the highest-yielding field model, and 9.6–10.8 t/ha from the other field models. These results showed that permanent meadows and pastures lying on mineral soils and under intensive fertilization and exploitation yielded as much as cultivated fields and still maintained a high level of productivity after 8 years of intensive exploitation.

KEY WORDS: meadow, pasture, grasses, kale, bean, beets, potatoes, maize.

INTRODUCTION

In most European countries with intensive agricultural production, the amount of natural grassland is decreasing in favor of arable land and leys. This change is due to higher and more valuable yields obtained from leys than from permanent grasslands (Lidtke 1975).

In Poland, 21.4% of all agricultural lands are grasslands (GUS 1980), 64% of which lie on mineral soils. To date, the progress in ploughing them up has been slow, but an increase in this rate can be expected. In this connection, it is necessary to examine the following questions: (1) Do natural grasslands truly have a worse overall production value than intensive field fodder-production models? (2) After how many years of intensive exploitation should natural grassland be renovated? (3) Which field fodder-production models on previously plowed grassland plots are more efficient?

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METHODS

The experiments reported here have been carried out since 1973 in four experiment stations in different regions of Poland. They were located on permanent pastures (over 20–30 years old) on mineral soils with 28%–50%